Attempt to confirm superheavy element production in the ^{48}Ca + ^{238}U reaction

K.E. Gregorich[1], W. Loveland[2], D. Peterson[3], P.M. Zielinski[1,4], S.L. Nelson[1,4], Y.H. Chung[5], Ch.E. Düllmann[1,4], C.M. Folden III[1,4], K. Aleklett[6], R. Eichler[7,8], D.C. Hoffman[1,4], J.P. Omtvedt[9], G.K. Pang[4], J.M. Schwantes[4,10], S. Soverna[7,8], P. Sprunger[2], R. Sudowe[1], R.E. Wilson[1,4], and H. Nitsche[1,4]

[1] *Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720*

[2] *Department of Chemistry, Oregon State University, Corvallis, Oregon 97331*

[3] *Physics Division, Argonne National Laboratory, Argonne, Illinois 60439*

[4] *Department of Chemistry, University of California, Berkeley, California 94720*

[5] *Department of Chemistry, Hallym University, Chuncheon, Korea 200-702*

[6] *Department of Chemistry, Uppsala University, Uppsala, Sweden*

[7] *Labor für Radio- und Umweltchemie, Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland*

[8] *Departement für Chemie und Biochemie, Universität Bern, CH-3012 Bern, Switzerland*

[9] *Department of Chemistry, University of Oslo, Oslo, Norway*

[10] *Isotope & Nuclear Chemistry, Los Alamos National Laboratory, Los Alamos, New Mexico 87545*

During the past five years, several reports have been published, from the Joint Institute for Nucelar Research in Dubna, on the production of superheavy elements (SHE) in the reaction of ^{48}Ca beams with actinide targets [1-6]. If correct, these experiments represent the discovery of SHE, and have far-reaching implications for the study of the nuclear and chemical properties of the heaviest elements. We have attempted to independently confirm *one* of the SHE claims using the Lawrence Berkeley National Laboratory Berkeley Gas-filled Separator (BGS). For this confirmation attempt, the ^{238}U(^{48}Ca,xn)$^{283\text{-}x}$112 reaction was chosen. The VASSILISSA group has reported that ^{283}112 is produced at ^{48}Ca energies of 231-233 MeV with a 4-pb cross section and that it decays by spontaneous fission (SF) with a half-life of 5.1 minutes [5]. In the more extensive set of experiments with the DGFRS, ^{283}112 is reported to be produced at a ^{48}Ca energy of 234-MeV with a 2.5-pb cross section and to decay by emission of 9.54-MeV α-particles with a half-life of 4.0 s, followed by the 180-ms SF decay of the ^{279}Ds daughter [3]. All reported and theoretically predicted SHE decay chains terminate with SF decay.

In the BGS experiments, two irradiations were carried out with center-of-target energies of 230.3 MeV and 235.6 MeV [7,8]. No SF events were observed. The one-event limits reached in the 230.3-MeV and 235.6-MeV irradiations are 0.80 pb, and 0.96 pb, respectively.

The excitation function for SHE production by compound nucleus formation with ~3 neutrons in the exit channel is expected to be broad, with a FWHM of ~6.6 MeV. A more stringent upper limit on SHE production from the BGS experiments is obtained by combining the results from the irradiations at the two ^{48}Ca beam energies. To combine the results from the two irradiations, Monte-Carlo simulations of the production and scattering in the targets, and propagation through the BGS was carried out by a method similar to that used earlier [9]. Since neither the excitation function centroid nor the element 112 magnetic rigidity in the BGS are known precisely, these simulations were carried out for several combinations of these values. The expected magnetic rigidity for element 112 is 2.22±0.03 Tm [8]. The resulting cross section limits from the combined experiments are presented in Fig. 1. The cross section limits presented in Fig. 1 represent 84% confidence limits (similar to a one-sigma upper limit on a normal distribution), and also contain the effect of a 12% systematic error in cross section determination.

We were unable to confirm the Dubna results, either from the DGFRS or VASSILISSA to a high degree of statistical significance.

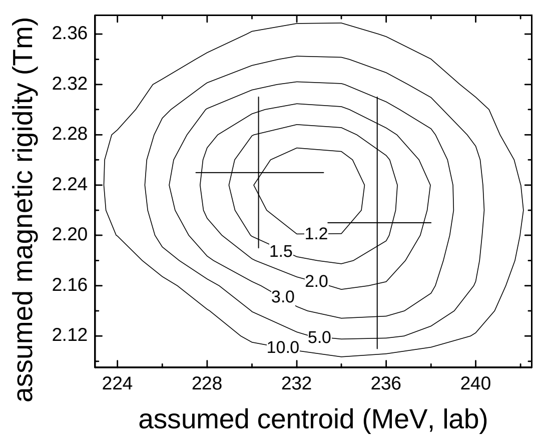

FIG. 1: ^{238}U(^{48}Ca,xn)$^{286\text{-}x}$112 cross section upper limits (84% confidence level), as a function of assumed excitation function centroid energy and assumed element 112 magnetic rigidity in He gas. Contours are labeled in picobarns. The crosses indicate ^{48}Ca beam energies in the target and the focal plane magnetic rigidity coverage, for irradiations centered at 230.3 MeV and 235.6 MeV.

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